Ann R Coll Surg Engl 1995; 77: 380–388

SURGICAL HISTORY

The history and evolution of surgical instruments

VI The surgical blade: from finger nail to ultrasound

John Kirkup MD FRCS
Honorary Curator, Historical Instrument Collection
The Royal College of Surgeons of England, London

Key words: Surgical instruments; History; Surgical blade origins and structure

Elective surgery requires planned incisions and incisions require appropriate blades. In the prehistoric era, division of the umbilical cord and other minor procedures were probably undertaken with human teeth and nails, and later with plant, animal and mineral substitutes, as witnessed by studies of primitive societies still surviving or recently extinct. More efficient metallic blades appeared in historic times and ultimately generated five specific shapes which are analysed in detail.

Today, as minimally invasive techniques, endoscopes, laser and ultrasound sources evolve, many hallowed incisions of surgical access diminish in length or disappear entirely. In historical terms, elective surgery of the twentieth century will be recalled as an interlude characterised by maximally invasive incisions.

I love thee, bloodstain'd, faithful friend!
As warrior loves his sword or shield;
For how on thee did I depend
When foes of Life were in the field!
To My Spring-Lancet. Snodgrass, 1841 *(1)*

Today, the bonus of anatomical and surgical information visible through the window of opportunity provided by traumatic wounds is self-evident; in the remote past such benefits were perceived obscurely, until 'surgical pioneers' stumbled on methods of wound enlargement, in the pursuit of embedded foreign bodies. Much later, elective surgical incisions were devised to perform circumcision, drain abscesses, trepan the skull and so on. If large planned incisions sustained the propagation of modern surgery, recent non-invasive techniques have reduced their significance and, after decades of stricture against the impropriety of small incisions, the keyhole in the door of surgical access is now as important as the door opening itself.

Major elective incisions section skin, vessels and deeper soft tissues, and often internal organs, cartilage and bone. If particular blades have evolved specific to each tissue incised, their remote origins remain mundane. In all probability 'surgical' blades were borrowed from domestic items and weaponry, at least until some 2000 years ago; in certain primitive societies such sources persist today *(2)*.

This communication, based on the Historical Instrument Collection in The Royal College of Surgeons of England, considers the origins and material composition of surgical blades, and analyses more fully their metallic forms under the following sub-headings: (i) single-edged, (ii) double-edged, (iii) end, (iv) serrated and (v) guarded (Table I).

Origins and materials (Board 1)

Fingernails

On the basis of observations made during recent centuries, it is clear human nails have been employed as primitive surgical knives, scalpels, lancets, scarifiers, curettes and elevators. Engelmann *(3)* recorded that the Klatsoops tribe of North America pinched through the umbilical cord with their finger nails. Apocryphal tales suggest certain rabbi used sharpened thumbnails for circumcision of the newborn while Scultetus *(4)* expressed distaste that midwives cultivated a long fingernail to divide the fraenum of infants' tongues as a

This communication is based on a permanent exhibition entitled, 'The Surgical Blade: from human nail to ultra-sound', currently displayed in the East Exhibition Hall of The Royal College of Surgeons of England

Correspondence to: Mr J Kirkup, Weston Hill, 1 Weston Park East, Bath BA1 2XA

Table I. Analysis of surgical blade structure with examples (simplified)

Single-edge	*Double-edge*	*End*	*Serrated*	*Guarded*
Fixed (amputation knife)	Short (lancet)	Transverse (chisel)	Linear (amputation saw)	Fixed (blunt tenotome)
Folding (abscess bistoury)	Long (catlin)	Oblique (gorget)	Cylindrical (trephine)	Sliding (fistula bistoury)
Dismounting (pocket-case knife)	Twin-bladed (metrotome)		Circular (osteotomy saw)	
Disposable (modern scalpel)				

routine, supposedly to prevent tongue-tie! When reviewing traditional Ethiopian surgery, Pankhurst *(5)* reported the use of long index fingernails to scarify infected tonsils or to extract them completely.

Further, it is credible that scarification was undertaken with nails cultivated to a point or even with normal nails for, as commonly experienced, these easily produce deep scratches and bleeding. Less likely is the employment of a notched or serrated nail despite a saw-like potential; at their sharpest, human nails cannot mark normal subperiosteal bone.

If no positive evidence proves human nails stimulated the invention of blades directly, it is of interest that, in the later nineteenth century, nail substitutes in metallic form were recommended by some surgeons for post-nasal procedures (Fig. 1*a*).

Organic blades

Plant

The acutely sharp leaf margins and stems of certain palms, reeds, bamboos and coarse grasses are razor-like hazards familiar to those who handle them carelessly. Indeed silica, a constituent of flint, is concentrated in these rigid structures and their employment as surgical blades is no surprise. Engelmann *(3)* noted that the umbilicus was sectioned by the Loanga tribe in Africa by the sharp leaf stem of a palm and in Annam, with a piece of bamboo. Lillico *(6)* stated that certain tribes in Melanesia and Polynesia, conducted scarification with slivers of bamboo and also thorns, and in America the Cherokee Indians used both blackberry thorns and dried laurel leaves to bleed by multiple scratches. The same author reported scarification in New Guinea with tiny arrows tipped with thorns, for controlled depth penetration, using a miniature bow.

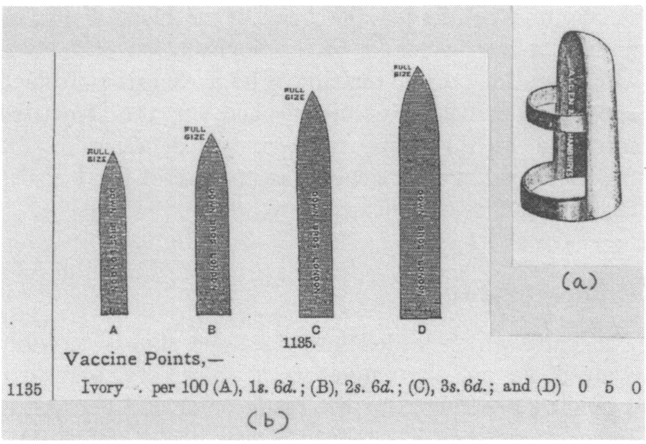

Figure 1. (a) Nickle-plated steel 'thimble', late nineteenth century, Dalby's for scraping post-nasal space. *(b)* Ivory vaccine points, late nineteenth century, Down's disposable.

Animal

Engelmann *(3)* observed the Papagos tribe dividing the umbilical cord with shell or pottery fragments and Corney *(7)* witnessed external urethrotomy in Fiji performed with broken mussel or cockle shells. Scarification was undertaken by the Ellice Islanders with shark's teeth mounted on handles and by the Karaya Indians of Brazil with a series of river fish teeth fixed with wax to a quadrangular or triangular piece of shell; the Ellice Islanders also used shark's teeth to venesect, to puncture hydroceles and to open abscesses *(6)*; and the Cherokee Indians constructed a scarifier of splinters of turkey bone set into a framework of turkey quills *(6)*. Various bones and ivory proved suitable for primitive blades; in late nineteenth-century Europe, thin ivory blade-points were utilised for vaccination (Fig. 1*b*), being sold in packs of 100, each for a single application, to establish the earliest form of disposable surgical blade.

Mineral

More efficient lancets and scalpels were made of flint, obsidian (volcanic glass) and other siliceous rocks, initially as accidents of nature, split by heat, frost, glaciation, earthquake, sea action and by man's haphazard breakage. Oakley wrote in 1961:

> . . . naturally fractured stones probably served as the first implements. Even at the present time there are backward tribes who make use of convenient bits of sharp stone, shark's teeth and shells as tools *(8)*.

During the Palaeolithic period (before 8000 BC) and especially the Neolithic (8000 BC to 3000 BC) manual skills evolved to create a variety of mineral blades, though it is improbable any were specific to surgical procedures. If blades were employed for scarification and venesection, these were borrowed, at least initially, from domestic sources; when such practices commenced is quite unknown.

Lillico *(6)* stated that primitive blood-letting by scarification, recorded by explorers and travellers over the last century, was performed with flint flakes by American Cherokee and Alaskan Indians, and with lancets of nephrite (jade) cleft into wooden handles by Eskimos of the Bering Strait; and venesection was undertaken with flint lancets or arrow heads lashed to sticks by American Chippewa and Mapuche Indians. Davis and Appel *(9)* drew attention to venesection with unmounted knapped flint knives by native doctors in Alaska during the 1880s.

Jacobs *(10)* claimed male circumcision was the oldest elective operation and noted its performance with stone knives by the Chippewa of Mississippi, ancient Aztecs, Caribs of Orinoco, Tacuna of Amazonia and Aborigines of Australia; as the Bible records, the wife of the prophet Moses took a sharp stone and cut off the foreskin of her son (Exodus 4:25).

In the USA recently, Crabtree revived the ancient method of reproducing fine blades from volcanic glass and, when he needed an operative procedure, he persuaded Buck, his surgeon, to employ them for half of the incision; it was reported the volcanic glass proved sharper than stainless steel and the subsequent healing was normal *(11)*. Later, Buck recommended these blades for nerve repair, microvascular, plastic and ophthalmological surgery. Unfortunately, the time-consuming skills of production failed to compete economically with mass-produced disposable steel blades. Nonetheless, those who have handled fine quality volcanic glass (obsidian) splinters, have little doubt about this material's trenchant acuity.

Metallic blades

The introduction of copper ore smelting and the casting of copper implements about 3500 BC, shortly followed by the discovery of its much harder alloy bronze, revolutionised weaponry, craft tools and domestic items *(12)*. Immediate manufacture of specific surgical instruments is unlikely, although in some communities bleeding and scarification were possible with bronze blades borrowed from other disciplines.

The discovery of iron smelting about 1400 BC and of the 'steel' facing of iron items about 1200 BC were further revolutions enhancing the quality of weapons and tools *(12)*. Documented application to surgery is unknown before about 400 BC, when Hippocrates mentioned iron blades for scarification *(13)*. Among Roman surgical finds, 'steel' scalpel blades have mostly disintegrated to leave empty bronze handles. It is assumed similar corrosion in the Dark Ages was responsible for today's grossly impoverished record, rendering assessment of 'steel' surgical blades uncertain during this period of over 1000 years *(14)*.

If small numbers of instruments have survived from the sixteenth and seventeenth centuries, it was the mid eighteenth century before the crucible steel process produced sharper, stronger and more corrosion-resistant blades *(15)*. Their keenness has not been superseded by plated or stainless steels, and today dismountable crucible or carbon steel scalpel blades are widely popular; easily mass-produced, they are used in vast numbers and disposed of before rust appears.

Future blades

Currently, disposable carbon steel blades in Europe and stainless steel blades in North America are challenged by new materials and concepts. In ophthalmic surgery gemstone diamond blades on titanium handles are employed and in both this branch of surgery, and others, tissues are incised with laser energy sources. Latterly, ultrasound modalities became available while, as yet, undiscovered cutting rays and even surgical quality plastic blades are future possibilities.

Single-edged blades (Board 2)

Derived from domestic and hunting knives, and probably the barber's razor, the single-edged metallic linear blade represents a basic shape and an early form applied to surgery. The blunt back opposed to the cutting edge enables pressure control by the thumb or index finger to be exerted during application, depending on its exact function and handle. The appellations knife, scalpel and bistoury follow no clear rules, although bistoury, now archaic except in French, refers to small narrow blades, and scalpel is restricted generally to small convex-edged or bellied blades. Knives span a spectrum between massive amputation and minute cataract blades.

Fixed blades

A fixed handle improves accuracy of control, surgical efficiency, security for the surgeon and safety for the patient. However, when not in use, the unprotected blade is readily damaged and may inadvertently injure the handler; a sheath, a compartment in a box, a sterilising rack and a folding knife are examples of arrangements which protect the blade.

For many centuries, fixity was a feature of amputation knives (see Fig. 4), doubtless because any instrument which folded or deviated during this rapidly performed procedure, prior to anaesthesia, was a liability to both patient and operator. The introduction of thermal sterilisation reinforced the concept of blade fixity, as folding items remained bacteriologically suspect, even when handles became metallic. The harbouring of blood and pus, the flaking of nickel-plate and the associated corrosion at the pivot were remedied, early in the twentieth century, by general acceptance of fixed blades for all branches of major surgery.

Folding blades

The knife which folded into a handle almost certainly evolved as an alternative to a sheath or scabbard, providing protection for the blade point and permitting knives to be carried safely in a coat pocket. Further, a folded knife occupied less space, enabling the surgeon to carry more items in his pocket or minor instrument case, a significant advantage in the days of horseback travel.

During the later sixteenth century, simple wooden and horn handles began to be replaced by exotic materials; in particular tortoiseshell was utilised for folding handles. Initially, knives and scalpels were constructed with a simple 'stop position' when open fully, the proximal butt of the blade being shaped to impinge against the two tortoiseshell leaves of the handle (Fig. 2). To maintain this position required constant digital pressure, not only tedious but easily liable to failure with sudden dangerous folding of the instrument. By the nineteenth century various mechanisms evolved to lock the blade securely in both open and closed positions (Fig. 2), and these continued briefly when tortoiseshell was replaced by plated metals for aseptic purposes.

During the early twentieth century, folding abscess knives and general-purpose scalpels steadily disappeared, at least in Great Britain, as general practitioners took to motor cars with their larger carrying capacity. Finally, ambulances and helicopters ensured surgical operations were hospital based.

Dismounting blades

To economise on space and reduce weight, a single common handle was utilised to interchange with a variety of blades and other items. This system applied to skull trephining and dental toilet sets, at least from the late seventeenth century and became a feature of post-mortem sets in the eighteenth century as well as comprehensive pocket cases in the nineteenth century. To achieve stability the dismounting blade screwed in or locked onto the handle by a number of devices (Fig. 3). As already noted, the rationale for pocket case equipment steadily declined early this century and with it many

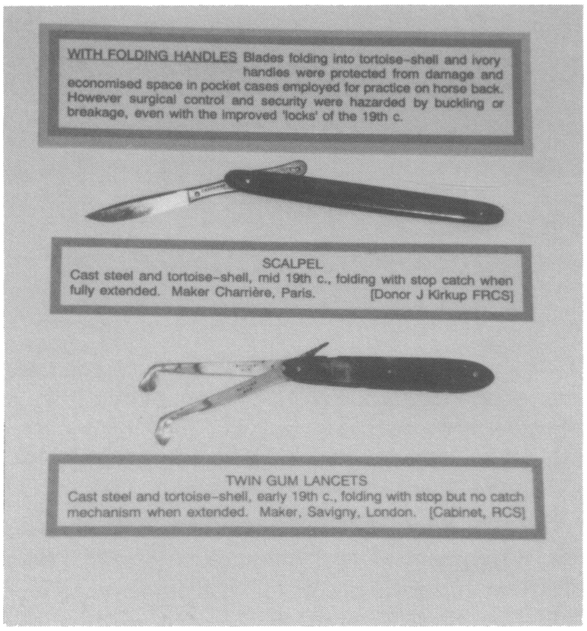

Figure 2. Folding blades (Board 2, part): Steel scalpel which locks straight when 'button' engages inside tortoiseshell handle, mid nineteenth century; Steel gum lancets held straight by thumb pressure against tortoiseshell handle, early nineteenth century.

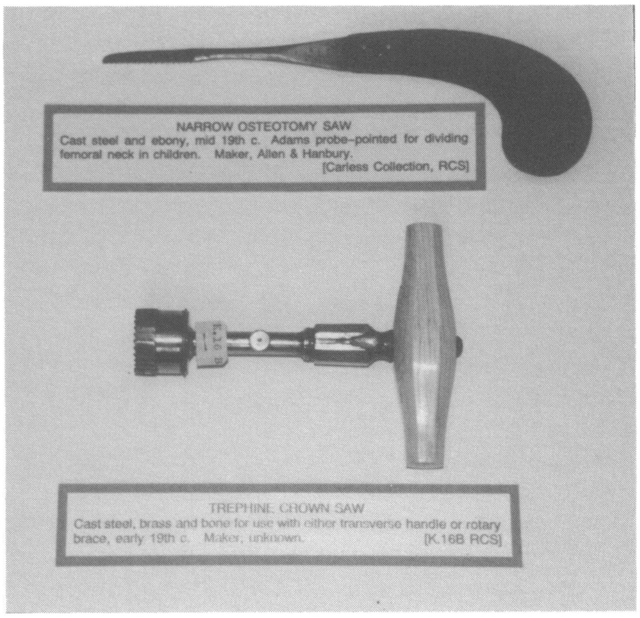

Figure 3. Linear and cylindrical saws (Board 5, part): Narrow steel blade and ebony, mid nineteenth century, Adams for osteotomy femoral neck; Steel skull trephine, dismounting from bone handle, early nineteenth century.

dismountable items; common scalpel and motorised saw blades remain exceptions.

Disposable blades

Before the convenience of dismounting disposable blades, scalpels required constant resharpening, this task being performed during surgical operations if the supply of sharp scalpels became exhausted. Hence the introduction of disposable blades in the late 1920s, revolutionised practical surgery. These were easily mass-produced in a variety of shapes and when blunt readily replaced at the surgeon's whim. Doubts concerning the economics of discarding blades soon disappeared in the face of the system's positive advantages; today, employment of a professional sharpener in an operating unit would prove more costly than the price of replacing many blades. Further, the superior sharpness of carbon steel blades over stainless steel is not diminished by potential rusting of the former, as these are disposed of and incinerated long before corrosion is possible.

Double-edged blades (Board 3)

Derived from daggers and swords, these blades are employed characteristically in stabbing fashion. Twin-bladed instruments, for example certain urethrotomes, operate somewhat differently but are categorised here as double-edged instruments.

Lancets, catlins, etc

The classical triangular pointed bleeding lancet blade, popular from the later sixteenth century was protected by

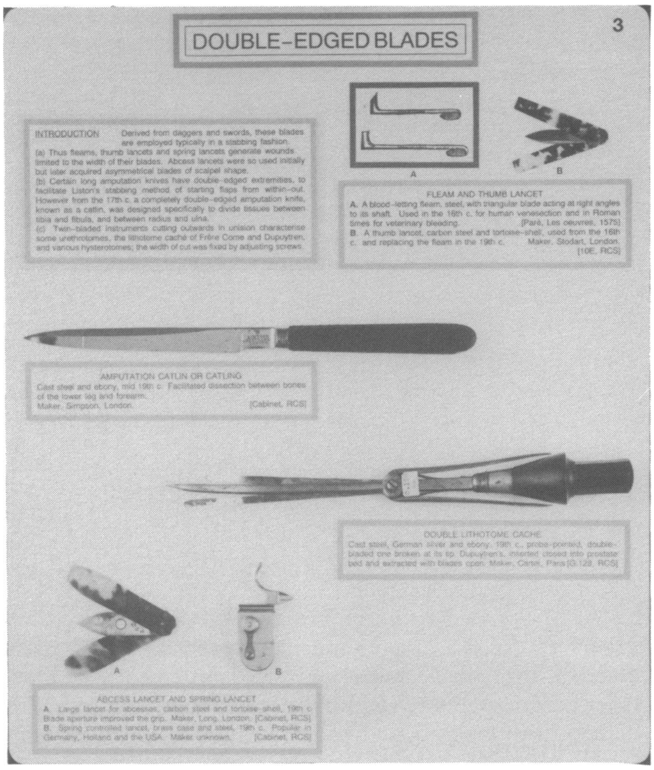

Figure 4. Double-edged blades (Board 3) from top to bottom: Steel fleams from sixteenth-century illustration, for venesection; Steel thumb lancets with tortoiseshell leaves, late eighteenth century; Steel catlin blade and ebony, mid nineteenth century; Steel and ebony lithotome, central probe guard, one blade broken, early nineteenth century, Dupuytren's for perineal lithotomy; Steel and tortoiseshell abscess lancet, early nineteenth century, aperture in blade secures grip; Steel and brass spring lancet, mid nineteenth century, triangular blade projected by spring release.

two leaves in tortoiseshell and pivoted without a stop position (Fig. 4). In practice the leaves were folded back and the blade grasped between thumb and index finger, leaving the double-edged point free to attempt vein puncture. The blades were sharp for 2 or 3 cm from their point and although aimed at superficial veins, venesection was easily bungled. In 1672 Lower *(16)* suggested reduction of one blade to the immediate point but his advice went unheeded. To improve control, certain practitioners wound rag round the blade to reduce the depth of penetration and also to protect their digits from injury.

To enhance precision and efficiency the spring-lancet or 'schnapper' developed in Austria and Germany, becoming popular in the United States *(17)* (Fig. 4); its spring-action triangular blade was less dangerous for the operator, and probably for the patient, than simple thumb lancets to which French and British surgeons clung, perhaps for reasons of cost? Later, a miniaturised lancet, restricted to vaccination, reduced skin perforation to a minimum. By contrast, larger versions were manufactured to open abscesses (Fig. 4) and even to perform lithotomy.

It is probable long-established familiarity and fashionable acceptance obstructed the evolution of more efficient and secure lancets. Their final demise followed abandonment of venesection as a central tenet of medical care in the later nineteenth century.

A completely double-edged knife, known as a catlin, catling or interosseous knife (Fig. 4) was designed in the seventeenth century to facilitate division of tissues between tibia and fibula, and between radius and ulna during amputations. It persisted as an integral component of amputation sets until after the First World War, during which all large amputation knives gave ground to standard dissecting scalpels.

Many smaller double-edged surgical blades include iridectomy knives, myringotomes, certain tenotomes and hair-lip knives.

Twin-bladed instruments

Before anaesthesia and asepsis, the severe operation of lithotomy promoted continuous efforts to reduce hazards and pain, and to improve efficiency. In the early nineteenth century the single-bladed lithotome caché of Frère Come *(18)* (see Fig. 8) gave way to the twin-bladed version of Dupuytren *(19)* (Fig. 4). Inserted with the blades hidden by a central probe-pointed bar which guided the lithotome to the bladder base, the outward cutting blades were opened, as determined by adjusting screws on the handle, to incise an appropriate track during withdrawal. Further refinements were added by Charrière and suitable versions adapted for urethral stricture and phimosis. On the same principle, the twin-bladed hysterotome or metrotome assumed importance as an instrument of the gynaecologist's armamentarium in the later nineteenth century *(20)*.

End blades (Board 4)

Aligned at right-angles or obliquely to the long axis of the instrument, these blades function by forceful pushing or hammering action, essentially when cutting bone, cartilage or fibrocartilage.

Chisels, gouges and osteotomes

Chisels and gouges, derived from carpenters' and masons' tools, were utilised, in all probability, for legal dismemberment of hands and feet long before elective surgical amputations. The inscribed stele with the law code of Hamurabi, *c.* 1750 BC, indicates that medical practitioners whose treatment resulted in their patient's death, were punished by hand amputation *(21)*, perhaps the earliest historical record of dismemberment for any reason. In the sixteenth and seventeenth centuries, elective amputation of digits and disarticulation through the wrist and ankle, with heavy chisels, gouges and mallets, were recommended by many surgeons to diminish peroperative pain *(22)* (Fig. 5). Digital amputation apart, such procedures were questioned in

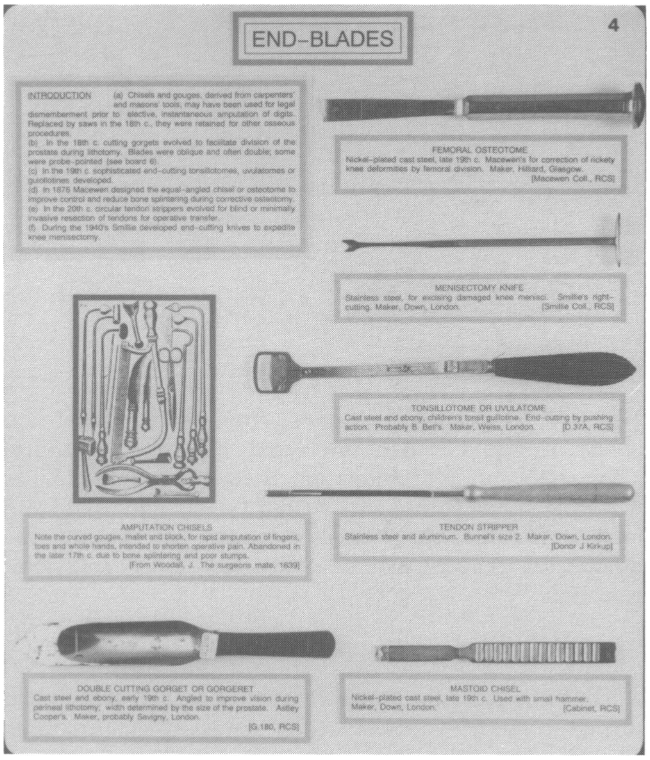

Figure 5. End-blades (Board 4) from top to bottom: Steel osteotome, late nineteenth century, Macewen's equal-angled 'chisel' for lower femur; Steel meniscotome, mid twentieth century, Smillie's for knee; Steel and ebony tonsillotome, early nineteenth century, probably Bell's; Steel and aluminium tendon stripper, mid twentieth century, Bunnel's; Steel and ebony gorget, early nineteenth century, Cooper's for perineal lithotomy; Steel mastoid chisel, late nineteenth century.

the mid seventeenth century because of ragged soft tissue division, bone shattering and poor healing of the guillotined stumps. After total abandonment, Mayor attempted to re-introduce instantaneous end-blade amputation in the 1840s, in an earnest effort to diminish operative agony; somewhat inconclusively he anticipated others would discover new instruments to enhance 'tachytomie', or accelerated cutting *(23)*.

However, this and other concepts, such as using warmed knives, were overtaken by events with the introduction of anaesthetic agents in 1846. During the nineteenth century, smaller chisels and gouges were utilised for mastoid (Fig. 5), skull and bone surgery generally, and in 1876, Macewen introduced the equal-angled chisel (Fig. 5) for accurate and controlled osteotomy of the lower femur, for rachitic knee deformity *(24)*. This wedge-shaped end-blade retains a place in orthopaedic practice, despite the introduction of motorised saws.

Gorgets, tonsillotomes, meniscotomes, etc

End cutting gorgets or gorgerets evolved in the eighteenth century as specific instruments to expedite lithotomy. Similar to twin-bladed lithotomes, the gorget cut a defined track through the prostate into the bladder base, being achieved on insertion, not withdrawal. Of various widths available, many were probe-pointed to engage a grooved urethral sound or staff. Most gorgets had dual oblique rather than transverse blades, though the instrument acted effectively as an end-blade (Fig. 5). The rationale for their use evaporated in the mid nineteenth century, in response to the lithotrite and to anaesthesia.

From the late eighteenth century, various end cutting blades were exploited for tonsillectomy and uvulectomy, achieving importance in the later nineteenth and twentieth centuries when known as guillotines (Fig. 5). These blades slide in a metal frame which opens to encompass diseased tonsils, before punching the blade home to close the frame and complete the excision.

Semilunar fibrocartilages of the knee often proved difficult to excise with single-edged blades and the end cutting meniscotomes of Smillie, introduced in the 1940s, promoted more comprehensive removal. Despite their efficiency, posterior meniscal horn excision was often blind and popliteal vessel injury not unknown. Half a century later their use has declined markedly, reflecting the advantages of direct vision arthroscopy.

Of more unusual end-blades, the three-quarter cylindrical blade of Bunnel's tendon stripper (Fig. 5) and the swivel knife of Killian are worthy of notice. The tendon stripper acts by a pushing action to divide tendons at a distance blindly, and the swivel knife by a pulling action during withdrawal to cut nasal cartilage tangentially.

Serrated blades (Board 5)

As Tubby emphasised, all blades however fine have a serrated edge, if examined under a microscope *(25)*; in the case of true saws the serrations or teeth are plainly visible to the naked eye.

Archaeological finds include saws composed of flint, copper, bronze and steel used for craft and domestic purposes, long before application to osseous surgery. Until 150 years ago, saws were utilised principally for craniotomy and amputation.

Linear saws

Evidence of elective amputation is sparse before the late fifteenth century when large bow or frame saws were first illustrated for below-knee bone section; as shear steel blades were brittle, amputation sets normally contained spare blades in case of operative breakage (Fig. 6). Concurrently, smaller bow saws were used for digital or metacarpal amputations and continue in this role today. About 1850, Butcher introduced a frame saw with an adjustable rotating blade capable of cutting at any angle, specifically for knee joint resection *(26)*.

Small semicircular, rectangular and square saws of flat or tenon form were used from the fifteenth century to excise compound fractures of skull and limbs; these accompanied trepanation sets in Britain, under Hey's name, until the twentieth century. The introduction of crucible steel improved saw blade quality materially and

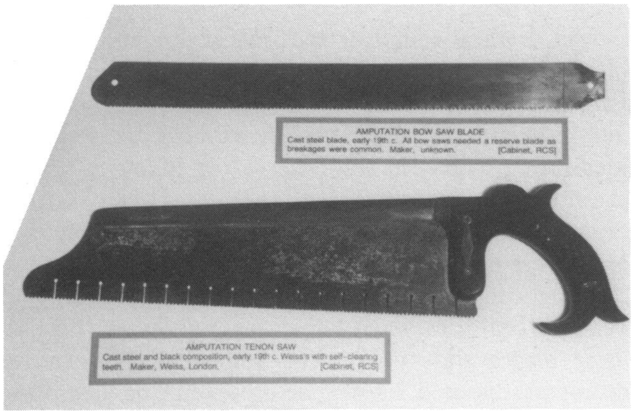

Figure 6. **Linear saws (Board 5, part): Steel serrated blade, detachable, for bow saw, early ninteenth century; Steel and composition tenon saw, reinforced back, self-clearing teeth, early nineteenth century, Weiss's.**

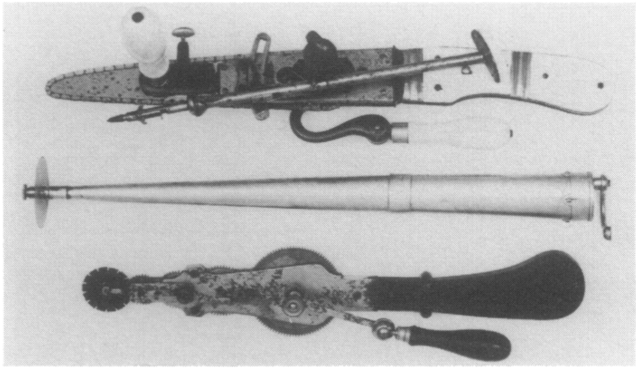

Figure 7. **Hand-powered saws, from below: Steel and ebony in-line circular saw, mid nineteenth century, Charrière's for joint resection; Steel transverse circular saw, mid nineteenth century, von Graefe's for skull and joint resection; Steel endless chain and ivory, mid nineteenth century, Heine's for osteotomy and joint resection.**

promoted the use of large tenon saws, often strengthened along the back. In the early nineteenth century these replaced bow saws for major amputations in Britain and America and became standard for post-mortem examinations worldwide; many of these saws had moveable backs which pivoted clear of obstructions. In addition, Weiss patented a blade with alternating small and large teeth to improve self-clearing (Fig. 6).

Narrow linear saws, introduced by Larrey in the early nineteenth century, proved excellent for minor amputations and for joint resection. In 1869 Adams introduced a pistol-handled narrow saw (Fig. 3) for what was termed 'subcutaneous' osteotomy of the femoral neck, to correct vicious ankylosis *(27)*; this utilised a small incision to pioneer an early form of minimally invasive surgery. Unlike 'subcutaneous' tenotomy, infection was a common hazard until full antiseptic precautions were applied.

Cylindrical saws

Bronze cylindrical or crown saws, rotated by a bow string, have been identified in Roman finds, probably for bone trephining and possibly skull trepanation *(28)*. Little is certain until the Renaissance when the two-handed carpenter's brace was introduced for craniotomy *(29)*. In Britain this was replaced by the lighter unimanual T-shaped handle (Fig. 3), until the bimanual brace returned to favour in the late nineteenth century. However, small trephines for bone biopsy retain the simple T-shaped handle.

Circular saws

Joint excision for disease, usually tuberculosis, stimulated attempts to divide bone with rotating circular blades such as the Machel saw of 1815 *(30)*. Despite later refinements in gearing by Charrière and von Graefe (Fig. 7), manual circular saws provided insufficient speed to cut bone efficiently. Improvement followed adaptation of the foot-operated dental engine by Doyen and Horsley for skull work in the late nineteenth century. By 1895 Doyen had turned to electrical power which increased rotation to an efficient 2500 rpm *(31)*.

Power saws

In 1908 Bryant introduced a light, hand-held, electrical motor saw for cranial surgery, said to rotate at 15 000 rpm *(32)*. Soon Albee refined this for bone work generally and bone-grafting in particular, utilising a variety of single and twin circular saws which cut bone quickly, accurately and aseptically *(33)*.

Today, electrical and air-driven power motor much safer oscillating circular saws; their adaptation to the atraumatic removal of plaster-of-Paris casts is well known. A further modification powers reciprocating motion to linear saws which also minimises soft tissue injury near bone.

Chain saws

The flexible or hand chain saw introduced by Aitken in 1785 for symphisiotomy during difficult childbirth *(34)*, was adapted from Swiss long-case clock chains incised with teeth on one side; these were controlled by detachable handles and cut from behind the bone forward; a capacity to work in confined spaces enhanced its value for joint excision. About 1830, Heine invented an endless chain saw controlled by manual power *(35)* (Fig. 7). This complex costly instrument was defective in practice, doubtless due to the low speed of the chain's motion, and the hand chain saw maintained its position until 1894 when displaced by the twisted and barbed wire saw of Gigli *(36)*. The latter proved very effective and occupying minimal space remains a valuable surgical instrument notably for craniotomy and pelvic osteotomy.

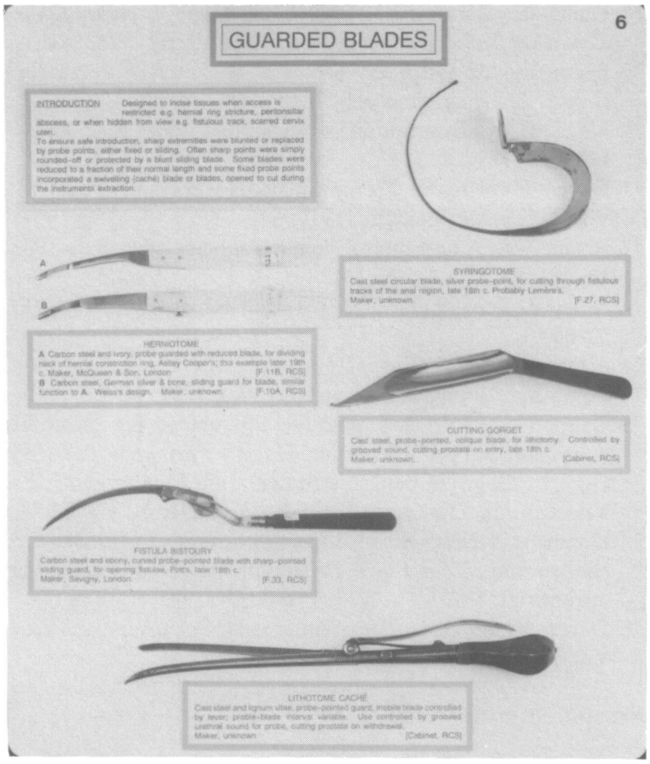

Figure 8. Guarded blades (Board 6) from top to bottom: Steel and silver syringotome, late eighteenth century, probably Lemère's for dividing fistula-in-ano; Steel and ivory herniotome, early nineteenth century, Cooper's with reduced blade; Steel and ivory herniotome, early nineteenth century, Weiss's with sliding guard; Steel gorget, oblique blade, late eighteenth century, for perineal lithotomy; Steel and ebony fistula bistoury, late eighteenth century, Pott's with pointed sliding guard; Steel and lignum vitae lithotome cache, late eighteenth century, Frère Come's single blade for perineal lithotomy.

Guarded blades (Board 6)

These were designed to secure safe incision principally when access was restricted, eg for hernial stricture, scarred cervix uteri, peritonsillar abscess, or when hidden from view, eg a fistulous track. To ensure safe introduction, knife points were blunted or hidden by rounded probe guards during introduction and then exposed to incise as desired, either by sliding the guard back or advancing the point (Fig. 8). Most guards moved parallel to the flat of the blade but occasionally the guard slid tangential to the cutting edge, careful manufacture being required to avoid damaging the blade. Other blades were restricted in length as well as probe-pointed in order to divide tight stricture rings safely during herniotomy (Fig. 8).

As noted earlier, twin-bladed lithotomes and hysterotomes were inserted with the blades hidden, and guided to the site of incision by a probed extremity. Single-bladed lithotomes, hysterotomes and urethrotomes were controlled in similar fashion (Fig. 8).

The operative sequence of probing and incising for fistula-in-ano resulted in the syringotome, composed of a malleable silver probe section secured to a narrow curved steel blade (Fig. 8); thus the blade was guarded during initial introduction. Syringotomes are probably of Graeco-Roman origin and their last protagonists worked in the late eighteenth century *(37)*.

About 1895 Doyen introduced a guarded skull saw of tenon form, the mobile guard being adjusted to control the depth of cut *(38)*; its contribution towards the fashioning of cranial flaps was superseded shortly by Gigli's saw. However, the penetration depth of certain cylindrical cranial saws remains a function of integral adjustable guards.

I am indebted to the President and Council of the College for their permission to reproduce instruments exhibited at the College from the Historical Instrument Collection. I thank Ian Lyle and his staff in the College Library for their invaluable help and acknowledge gratefully the enthusiastic assistance and expertise of Martyn Cooke of the Conservation Unit who also arranged the exhibition so meticulously.

References

1 Snodgrass JE. To my spring-lancet. *Baltimore Phoenix and Budget* 1841. Cited by Davis A, Appel T. *Bloodletting Instruments in the National Museum of History and Technology*. Washington: Smithsonian Institution Press, 1979: 14.

2 Kirkup JR. From flint to stainless steel: observations on surgical instrument composition. *Ann R Coll Surg Engl* 1993; 75: 365–74.

3 Englemann GJ. *La Pratique des Accouchements Chez les Peuples Primitifs*. Paris: Baillière, 1886: 192–5.

4 Scultetus J. *The Chyrurgeon's Storehouse*. London: Starker, 1674: 156.

5 Pankhurst R. An historical examination of traditional Ethiopian medicine and surgery. *Ethiop Med J* 1964; 3: 157–67.

6 Lillico J. Primitive bloodletting. *Ann Med Hist* 3rd series, 1940; 2: 133–9.

7 Corney BG. Instruments from Fiji. In: Doran A, ed. *Descriptive Catalogue in the Museum of The Royal College of Surgeons of England*, in manuscript, Vol. XX. 1925: 20–23.

8 Oakley KP. *Man the Tool-maker*. London: British Museum, 1961: 5.

9 Davis A, Appel T. *Bloodletting Instruments in the National Museum of History and Technology*. Washington: Smithsonian Institution Press, 1979: 67.

10 Jacobs MS. Circumcision. *Ann Med Hist* 3rd series, 1939; 1: 68–73.

11 Buck B. Ancient technology in contemporary surgery. *West J Med* 1982; **136**: 265–9.

12 Forbes RJ. Extracting, smelting and alloying. In: Singer C, Holmyard EJ, Hall AR, eds. *A History of Technology*, Vol. I. Oxford: Clarendon Press, 1954: 572–99.

13 Adams F. *The Genuine Works of Hippocrates*, Vol. II. London: Sydenham Society, 1849: 808.

14 Kirkup JR. *A Historical Study of the Surgical Armamentarium: Origins and Materials*. Thesis, Cambridge University, 1994.

15 Forbes RJ. Metallurgy. In: Singer C, Holmyard EJ, Hall

AR, Williams TI, eds. *A History of Technology*, Vol. II. Oxford: Clarendon Press, 1956: 41–80.

16 Hunter R, Macalpine I. *Richard Lower De Catarrhis 1672*. London: Dawson, 1963: 11–13.

17 Davis A, Appel T. *Bloodletting Instruments in the National Museum of History and Technology*. Washington: Smithsonian Institution Press, 1979: 12–14.

18 Baseilhac J. *Nouvelle Méthode d'Extraire la Pierre de la Vessie*. Paris: Houry, 1779.

19 Dupuytren G. *Sur une Manière Nouvelle de Pratiquer l'Opération de la Pierre*. Paris: Baillière, 1836.

20 Hart DB, Barbour AHF. *Manual of Gynaecology*, 4th Edition. Edinburgh: Johnston, 1890: 270–71.

21 Sigerist HE. *A History of Medicine*, Vol 1. New York: Oxford University Press, 1951: 434.

22 Woodall J. *The Surgions Mate*. London: Griffin, 1617: 8.

23 Mayor M. *L'Expérience, la Chirurgie Pure et la Tachytomie*. Lausanne: Decloux, 1833: 84–143.

24 Macewen W. Clinical lecture on antiseptic osteotomy. *Br Med J* 1879; **1**: 656–8.

25 Tubby AH. Observations on the selection and standardisation of surgical instruments. *Lancet* 1928; **ii**: 735–8.

26 Butcher RGH. *On Excision of the Knee-joint*. Dublin: Hodges & Smith, 1855: 55–7.

27 Willet A. An historic instrument. *Br Med J* 1898; **1**: 167.

28 Kunzl E. *Medizinische Instrumente aus Sepulkralfunden Romischen Kaiserzeit*. Koln: Rheinland Verlag, 1982: 84–5.

29 Berengario da Carpi G. *Tractatus de Fractura Calve Sive Cranei*. Bologna: Benedetti, 1518.

30 Machell Mr. Description of an annular saw. *Med Phys J* 1815; **33**: 189.

31 Doyen E. *Surgical Therapeutics and Operative Technique*, Vol. 1. London: Baillière, 1917: 328–31.

32 Bryant WS. A new motor for bone surgery. *Ann Surg* 1908; **48**: 303–5.

33 Albee F. *Bone-graft Surgery*. Philadelphia: Saunders, 1915: 52–63.

34 Aitken J. *The Principles of Midwifery*, 2nd Edition. Edinburgh: Lying-in Hospital Charity, 1785: 76–8.

35 Heine B. Mémoire sur un nouvel instrument, dit osteotome, pour l'ablation partielle des os. *Gazette Paris* 1834; **2**: 641–5.

36 Gigli L. Uber ein neus Instrument zum Durchtrennen der Knochen, die Drahsage. *Zentralb Chir* 1894; **21**: 409–11.

37 Doran A. *A Descriptive Catalogue of Surgical Instruments in the Museum of The Royal College of Surgeons of England*, in manuscript, Vol. VII. 1925: 179–82.

38 Doyen E. *Surgical Therapeutics and Operative Technique*, Vol. 1. London: Baillière, 1917: 322 and 531.

Received 30 January 1995